CLAIMS:

We Claim:

1. A method of developing a system for determining the occupancy state of a seat in a passenger compartment of a vehicle, comprising the steps of:

mounting transducers in the vehicle;

forming at least one database comprising multiple data sets, each of the data sets representing a different occupancy state of the seat and being formed by receiving data from the transducers while the seat is in that occupancy state, and processing the data received from the transducers; and

creating a first algorithm from the at least one database capable of producing an output indicative of the occupancy state of the seat upon inputting a data set representing an occupancy state of the seat.

2. The method of claim 1, wherein said step of creating a first algorithm from the at least one database comprises the steps of:

inputting the database into an algorithm generating program, and

running the algorithm-generating program to produce the first algorithm.

3. The method of claim 2, wherein the algorithm generating program is run to generate a neural network algorithm.

4. The method of claim 3, further comprising the step of:

utilizing the back propagation method when generating the neural network algorithm.

5. The method of claim 1, wherein the at least one database comprises a plurality of databases.

6. The method of claim 1, further comprising the steps of:

inputting data sets into the first algorithm to obtain a plurality of output data, and

creating a second algorithm for combining a plurality of output data to form a new output indicative of the occupancy state of the seat.

7. The method of claim 6, further comprising the step of:

combining the plurality of output data from the first algorithm using a low pass filter.

8. The method of claim 1, wherein the occupancy states of the seat include occupancy of the seat by an object selected from the group comprising rear facing infant seats, forward facing human being, out-of-position human being, forward facing child seats and empty seats.

9. The method of claim 8, wherein the occupancy states of the seat include occupancy by the objects in multiple orientations.

10. The method of claim 8, wherein the occupancy states of the seat include occupancy by the objects and at least one accessory selected from a group comprising newspapers, books, maps, bottles, toys, hats, coats, boxes, bags and blankets.

11. The method of claim 1, wherein the at least one database comprises a plurality of databases, further comprising the step of;:

providing a different distribution of occupancy states for at least one of the databases.

12. The method of claim 1, further comprising the step of:

pre-processing the data prior to processing the data to form the data sets.

13. The method of claim 12, wherein said pre-processing step comprises the step of using data created from features of the data in the data set.

14. The method of claim 13, wherein the features of the data in the data set used in said pre-processing step are selected from a group comprising the normalization factor, the

number of data points prior to a peak, the total number of peaks, and the mean or variance of the data set.

19 16. The method of claim 12, wherein said pre-processing comprising the step of:

mathematically transforming the data sets using one or more of the group comprising normalization, truncation, logarithmic transformation, sigmoid transformation, thresholding, averaging the data over time, Fourier transforms and wavelet transforms.

20 16. The method of claim 12, wherein said pre-processing step comprises the step of:

subtracting data in one data set from the corresponding data in another data set to create a third data set of differential data.

6 17. The method of claim 2, further comprising the steps of:

pre-processing the data sets based on a set of rules derived from the database and which eliminate some of the data sets from being processed by the algorithm-generating program.

7 18. The method of claim 17, further comprising the step of:

deriving the rules using the principles of fuzzy logic.

8 19. The method of claim 17, further comprising the step of:

utilizing the data sets eliminated from input into the algorithm-generating program to create a database that is inputted into an algorithm-generating program to generate a second algorithm.

21 20. The method of claim 1, further comprising the step of :

subjecting the output of the algorithm to additional processing applying principles of one of fuzzy logic and neural networks.

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21. The method of claim 1, further comprising the steps of: testing each of the data sets by a pre-processing algorithm for reasonableness, and

modifying or eliminating a data set if the values of the data in the data set fail the reasonableness test.

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22. The method of claim 1, further comprising the step of:

utilizing a trained neural network to eliminate data sets that contain errors.

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23. The method of claim 2, wherein the algorithm generating program uses at least one computational intelligence system.

24. The method of claim 1, further comprising the step of:

biasing the algorithm toward a particular occupancy state thereby increasing the accuracy of identifying that occupancy state.

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25. The method of claim 1, wherein said processing step comprises the step of converting the analog data from the transducers to digital data and combining the digital data from a plurality of the transducers to form a vector comprising a string of data from each of the transducers, the first algorithm being created such that upon inputting a vector from a new data set will produce an output representing the occupancy state of the vehicle seat.

26. The method of claim 25, further comprising the step of:

normalizing the vectors in the database so that all values of the data that comprise each vector are between a maximum and a minimum.

27. The method of claim 1, wherein the at least one database comprises at least 50,000 data sets.

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28. A method of developing a system for determining the occupancy state of the vehicle seat in the passenger compartment of a vehicle, comprising the steps of:

forming data sets by obtaining data representative of various occupying objects at various positions in the passenger compartment and operating on at least a portion of the data to reduce the magnitude of the largest data values in a data set relative to the smallest data values; and

forming a database comprising multiple data sets; and

creating an algorithm from the database capable of producing an output indicative of the occupancy state of the vehicle seat upon inputting a data set representing an occupancy state of the seat.

29. The method of claim 28, wherein the step of operating on at least a portion of the data comprises the step of using an approximate logarithmic transformation function.

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30. A method of developing a database for use in developing a system for determining the occupancy state of a vehicle seat, comprising the steps of:

mounting transducers in the vehicle;

providing the seat with an initial occupancy state;

receiving data from the transducers;

processing the data from the transducers to form a data set representative of the initial occupancy state of the vehicle seat;

changing the occupancy state of the seat and repeating the data collection process to form another data set;

collecting at least 1000 data sets into a first database, each representing a different occupancy state of the seat;

creating an algorithm from the first database which correctly identifies the occupancy state of the seat for most of the data sets in the first database;

testing the algorithm using a second database of data sets which were not used in the creation of the algorithm;

identifying the occupancy states in the second database which were not correctly identified by the algorithm;

collecting new data comprising similar occupancy states to the incorrectly identified states;

combining this new data with the first database;

creating a new algorithm based on the combined database; and

repeating this process until the desired accuracy of the algorithm is achieved.

31. The method of claim 30. further comprising the step of:

creating some of the occupancy states of the seat using live human beings.

32. The method of claim 30, further comprising the step of:

varying the environmental conditions inside the vehicle while data is being collected.

33. The method of claim 32, wherein said environmental conditions varying step comprises the step of creating thermal gradients within the passenger compartment.

34. The method of claim 30, wherein a personal computer is used in the data collection process and where data sets are graphically displayed on the monitor of the personal computer.

35. The method of claim 30, further comprising the step of:

using reference markers and gages as part of a systematic method of creating a predetermined distribution of occupancy states of the vehicle.

36. The method of claim 30, further comprising the step of:

automatically recording the position of various complements of the vehicle selected from the group comprising the seat, seatback, headrest, window, visor and armrest.

37. The method of claim 30, wherein the varying occupancy states are created by automatically moving various vehicle complements such as the seat and seatback during the data collection process.

38. The method of claim 30, further comprising the step of:

automatically photographically recording at least some of the occupancy states of the seat.

39. The method of claim 30, further comprising the step of:

validating proper functioning of the transducers and the data collection process by using a standard occupancy state of the seat and corresponding prerecorded data set, wherein a data set is periodically taken of the standard occupancy state and compared with the prerecorded data set.

40. The method of claim 1, further comprising the step of:

creating at least one additional algorithm from the at least one database capable of producing in combination with the first algorithm an output indicative of the occupancy state of the seat.

41. The method of claim 40, wherein at least one of the first algorithm and the at least one additional algorithm identifies the category of the occupying item of the seat and another of the first algorithm and the at least one additional algorithm determines the location within the passenger compartment of the occupying item of the seat.

42. The method of claim 40, wherein at least one of the first algorithm and the at least one additional algorithm uses a neural network trained for a large number of training cycles and at least one other of the first algorithm and the at least one additional algorithm is a neural network trained for a substantially smaller number of training cycles.

43. The method of claim 40, wherein at least one of the first algorithm and the at least one additional algorithm is trained on a subset of the data in the at least one database and least one other of said algorithms is trained on a different subset of the data in the at least one database.

44. The method of claim 40, wherein the data set is inputted first into one of the first algorithm and the at least one additional algorithm which determines which of the other algorithms will further process the data set.

45. A method of developing a system for determining the occupancy state of a passenger compartment seat of a vehicle, comprising the steps of:

mounting a plurality of ultrasonic transducers in the vehicle;

receiving an analog signal from each of the transducers;

processing the analog signals from the transducers to form a data set comprising multiple data values from each transducer representative of the occupancy state of the vehicle, said data processing comprising the steps of demodulation, sampling and digitizing of the transducer data to create a data set of digital data;

forming a database comprising multiple data sets; and

creating at least one algorithm from the database capable of producing an output indicative of the occupancy state of the seat upon inputting a new data set representing an occupancy state of the seat.

46. The method of claim 45, further comprising the step of:

pre-processing the new data set prior to inputting into the at least one algorithm to remove one or more data elements at particular locations in the data set.

47. The method of claim 46, wherein the removed data values are the data values corresponding to the first data obtained during each data collection cycle from the transducers.

48. The method of claim 46, further comprising the step of:

using a neural network to determine which data values are to be removed from the data set.

49. The method of claim 48, wherein the data values which are removed from the data set correspond to reflections from surfaces which are furthest away from an airbag module.

50. The method of claim 46, wherein the ultrasonic transducers are mounted at corners of an approximate rhombus which surrounds the seat.

52. 51. The method of claim 46, wherein the ultrasonic transducers are aimed such that the ultrasonic fields generated thereby cover a substantial portion of the volume surrounding the vehicle seat.

53. 52. The method of claim 46, further comprising the step of:

adjusting the transducer field angles to reduce reflections off of fixed surfaces within the vehicle.

54. 53. The method of claim 52, wherein said field angle adjustment means utilizes horns.

55. 54. A method of developing a system for determining the occupancy state of a vehicle seat in a passenger compartment of a vehicle, comprising the steps of:

mounting a set of transducers on the vehicle;

receiving data from the transducers;

processing the data from transducers to form a data set representative of the occupancy state of the vehicle;

forming a database comprising multiple data sets;

creating an algorithm from the database capable of producing an output indicative of the occupancy state of the vehicle seat upon inputting a new data set;

developing a measure of system accuracy;

removing at least one of the transducers from the transducer set;

creating a new database containing data only from the reduced number of transducers;

developing a new algorithm based on the new database;

testing the new algorithm to determine the new system accuracy; and

continuing the process of removing transducers, algorithm development and testing until the minimum number of sensors is determined which produces an algorithm having desired accuracy.

56. 55. The method of claim 54, wherein the transducers are selected from the group consisting of ultrasonic transducers, optical sensors, capacitive sensors, weight sensors, seat

position sensors, seatback position sensors, seat belt buckle sensors, seatbelt payout sensors, infrared sensors, inductive sensors and radar sensors.

56. A method of developing a system for determining the occupancy state of the driver and passenger seats of a vehicle, comprising the steps of:

mounting ultrasonic transducers having different transmitting and receiving frequencies in a vehicle such that transducers having adjacent frequencies are not within the direct ultrasonic field of each other;

receiving data from the transducers;

processing the data from the transducers to form a data set representative of the occupancy state of the vehicle;

forming at least one database comprising multiple data sets; and

creating at least one algorithm from the at least one database capable of producing an output indicative of the occupancy state of a vehicle seat upon inputting a new data set.